A WIRELESS CAMERA SUPERVISION ROBOT (CSR-BOT) FOR THE CYLINDRICAL PIPES AND CABLES SURFACES OBSERVATION

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A project report submitted in partial
fulfillment of the requirement for the award of the
Degree of Master of Electrical Engineering

Faculty of Electrical and Electronic Engineering
Universiti Tun Hussien Onn Malaysia

JULY 2014

SPECIAL GRATITUDES TO:

***Special for my parent**,*

MUHAMMAD MUHYIDDIN BIN HASAN & ZAITON BINTI AHMAD

***Especially for my kindly supervisor that give encouragement and support**,*

DR. MD NOR RAMDON BIN BAHAROM

***My lovely siblings**,*

All my friends that give full support,

Person that guide and help me,

Only Allah S.W.T can repay your kindly

ACKNOWLEDGMENT

First and foremost, I pray to the God Al-Mighty, for His blessing to this great achievement. Without His grace and comparison, none of this would have been possible.

I would like to express my deepest gratitude to my respective supervisor, Dr. Md Nor Ramdon Bin Baharom, for his ideas, comments, direction and invaluable guidance throughout the course of this project.

Special thanks to my family members and friends who have been helpful by offering comment and advice ensuring the successful of the project.

Kindly regards goes to my educational sponsor bodies, the Ministry of Higher Education Malaysia.

Lastly, I would like to thank those who have contributed directly or indirectly toward the success of this project.

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q_z	Dynamic wind pressure
A_c	Wind loading area of the conductor
A_i	Wind loading area of the insulator
W_c	Total weight of the conductor
W_i	Total weight of the insulator
Cc	The drag coefficient factor
d_{cr}	The conductor diameter in meters
n_{cr}	The number of conductor bundles
L_1, L_2	Span of line erected on three towers in meter
Ω	The wind direction angle in degree with respect to the span line
a_i	Total area seen in side view
G_i	The drag factor
f_s	Vortex shedding frequency (Hz)
S	Strouhal number 0.185÷2
V	Wind speed (m/s^{-1})
d	Diameter cable (m)

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter discusses the background of the research problem. It generally describes about methods currently used by the electricity provider company to monitor the high voltage cable. This chapter also highlights the problem statement based on the background provided as well as the objectives, limitations and significance of the study.

1.2 Background of the Study

In this modern day, robot has replaced a lot of human job that may harmful to human life. There are common semi-automatic machine used by human to perform a difficult work where a person still needed to supervise the machine and decide about the task [1]. However, the use of robot to monitoring the condition of high voltage cable at the overhead transmission line such as shown in Figure 1.1 is not yet widespread.

Over several years, the overhead transmission line cable inspection has been done manually by experienced and well trained workers as shown in Figure 1.2. Recently, scientist and researcher are work together to plan-out a new method to substitute a worker with a robot to do the transmission line cable inspection. This method may save a lot of expenses from the electricity provider company and could reduce a risk of human life.

Figure 1.1: An overhead transmission line of rated voltage level [2]

The purpose of this inspection is done to monitor if there are any scratches, dust and rust of the cable. These problems may affect performance of the electrical current flow through the conductors (as detailing discusses in problem statement).

The disadvantage of using manpower is they may not monitor the situation accurately. In enhance the safeness of human life risk and improving the monitoring method, a wireless Camera Supervision Robot (CSR-BOT) for the cylindrical pipes and cables surfaces observation is purposed. This robot may improve on the quality of visual inspection practices commonly used this day and these technologies are targeted to include a GUI interface for collecting data from the wireless camera.

Figure 1.2: A manually inspection for overhead transmission line done by linesman [2]

This project is to develop a semi-automatic mobile robot that can move along through the overhead transmission line cable. The Camera Supervision Robot (CSR-BOT) is equipped with wireless camera supervision. This is to ensure that the handler could inspect the cable condition of the transmission line cable.

The data from wireless camera can be viewed directly from the computer. With a simple Graphical User Interface (GUI), the handler could record a video and captured the image during the inspection. Based on the data taken, cable maintenance can be easily done by the technician.

The important aspect should be considered during designing this robot is noise and interference produce when corona is discharging. This problem is occurred when if there are any scratches on the transmission line cable. During corona discharges, pulse of voltage and current will be created on the transmission line. The radio frequency noise also will be existed and it may interference the radio and television reception. Researcher found that sometimes the radio and television interference is not considered to be significantly influenced by transmission line coronas, it may cause by other things [3].

This aspect may cause a problem especially when handler wants to receive a data from wireless camera to a portable computer. In solving this problem, a proper shielding of the robot unit is essential in order to avoid noise problems receive from surrounding area.

1.3 Problem Statement

During a hot sunny season, transmission line can easily get scratch, dust and water may also affect the conductor's electrical performance [4]. This situation may produce creation of coronas. A corona will occur if there are any energy losses along the transmission line. The inspections for the transmission line are needed to prevent a variety of phenomenon.

After the construction is complete, all the transmission line need to be inspected before energizing the line.

Linesman will climb each structure of the transmission line to check the following conditions [5]:

1. Conductor condition
2. Conductor sag and clearance to ground, trees, and structures.
3. Insulator conditions.
4. Line hardware for roughness and tightness. Excess inhibitor found should be removed from conductors to prevent corona discharges.
5. Structure vibration and alignment.
6. Ground-wire connections and conditions.
7. Ground resistance at each structure.
8. Structure footings for washouts or damage.
9. Obstruction light operations for aircraft warning.

Once a year, the inspection for overhead high voltage transmission line needs to be done. For a decade, most of the leading Electricity Provider Company in the world has done an inspection for power transmission line manually. Several Workers (lineman) are employed to check the condition of the transmission line by on foot. But in some situation, workers will face a difficulty for travelling due to mountainous surface and wild animal attacks [6].

Sometimes, helicopter will be used to move one workers from one transmission line to others transmission line. This method is quite efficient and quicker. Unfortunately, this mission is quite costly and dangerous especially during a windy season. Another method is worker will using telescope to observe it from the ground [6].

Lineman may face with electromagnetic radiation which can minimize their health risk for a long term. Exposing to the AC fields too much can cause non-thermal cell damage or weaken the immune system. IEEE has set the safe exposure limit for ELF AC from power lines which may leads to cell damage at 100mW/cm^2 [7].

A new method need to be planned-out to ensure the accuracy of inspection for overhead high voltage transmission line and can reduce a risk of human life.

1.4 Objective of the Study

The aim of this research is to inspect the cable and insulator condition for the overhead high voltage transmission line. This system application should improving nowadays inspection method that applied by the energy provider company. To achieve these aims, the main objective of this research is to design and access an inspection robot with wireless camera supervision through the capability of GUI interface.

The measurable objectives of the project are:

i. To develop and design mechanical robot for inspecting a high voltage cable.
ii. To monitor the high voltage cable by using mechanical robot and three webcam camera.
iii. To test the performance of the Camera Supervision Robot (CSR-BOT).

1.5 Scope of the Project

The project is focus on to test the performance of the inspection robot with wireless camera supervision.

The scopes of the project are:

i. Design the robot using SolidWork premium 2013 software. The joystick is used to navigate the movement of the robot. The robot is design to be less than 5kg.
ii. The robot will be monitor using three webcam cameras. Model of the camera is Sensonic 6100.
iii. The robot will observe the cable condition in GUI-Interface program created in Matlab 2011b software. The output result only will be save in image capture and video recorded.
iv. The experiment been carried out to test the performance of the CSR-BOT as follows:
    a) The robot is tested in range of 0 to 30 meter.
    b) The robot will be tested on the Nylon rope (diameter size: 1 cm) and PVC pipe (diameter size: 2 cm).

c) The robot is only been tested in a horizontal alignment of the subject (Nylon rope and PVC pipe).
d) There is no obstacle along the testing subject during the experiment.
e) The robot will be tested in two situations it is indoor and outdoor.

1.6 Thesis Structure

This chapter has highlighted the common methods currently used by the electricity provider company to monitor the high voltage cable and the difficulties encountered by their technician during the inspection. The chapter also explains summary about the significance of the inspection for the high voltage conductor cables and the purpose used of the Camera Supervision Robot (CSR-BOT) to assist in monitoring the conductor cables. The remainder of the thesis is structured as follows:

Chapter 2 outlines the literature related to the high voltage transmission line. The finding is focusing on the cable conductor's physical aspect. This chapter also discusses some examples of design concept from the previous research that can be used to develop the CSR-BOT.

In **Chapter 3** describing the research method for hardware and programming part used for this project. Most of the contents is discussing about method on developing the CSR-BOT. The method for developing the CSR-BOT is divided in three phase which is mechanical part, electronic part and software part. Each of these part details are covered in this chapter.

Chapter 4 presents some analysis that has been carried out to test the performance of the robot and the GUI-Interface program. Several experiments have been done to test out the performance of the robot such as movement test, range test, tested on different type of material (other than conductor cable), distance verification, vibration test and sagging test. In the GUI-Interface for CSR-BOT program part, the efficiency of this software to captured, recorded and save the file during the live view is been test out. All of the result and findings from the test were reported in this chapter.

Chapter 5 draws a conclusion and makes recommendation for future works. This chapter concludes the research finding in development of a wireless Camera Supervision Robot (CSR-BOT) for the cylindrical pipes and cables surfaces observation. The chapter also discusses any possible suggestions for the CSR-BOT and the GUI-Interface program for improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature related to the high voltage transmission line. This chapter also looks into the related literature about mobile robot. A literature review is a stepping stone for current research. Any relevant ideas related to the research will help to provide better understanding towards achieving the improvement of current study.

2.2 Overhead Line Tower Types

In designing the overhead line tower, designer should consider about human safety aspects first before precede with their design. For designing the overhead line tower, there are many criteria should be concern about such as structural analysis, electrical clearance analysis, insulator design and effect of the conductor movement due to windy condition. The structure of the overhead line tower is more related to the concept of voltages and current uprating.

Steel lattice material is commonly chosen in making the overhead line tower. Wood or light steel is totally impractical material to be used in designing the tower because at the higher voltage levels it need to deal with high wind loads and ice loads during the winter season. In Figure 2.1, shows some examples of typical tower for single and double circuit configuration with single and double earth wires.

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